TECHNICAL MANUAL

QUALITY CONTROL OF AVIATOR'S BREATHING OXYGEN

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INTRODUCTION

1. PURPOSE.

This technical manual provides information, guidance, standards and procedures for establishing and maintaining quality control of liquid and gaseous oxygen used for aviator's breathing purposes.

2. SCOPE.

Strict quality control procedures must be exercised in the procurement, Air Force generation, storage, handling and transfer operations, and use of liquid and gaseous oxygen used for breathing purposes by aircrews.

Each operation in the aircraft liquid or gaseous oxygen supply system must also be carried out rigidly conforming to established procedures to assure safety of flight and mission completion.

CHAPTER 1
GENERAL

1.1 DESCRIPTION AND PROPERTIES OF OXYGEN.

Oxygen can exist as a solid, liquid, or gas, depending upon the temperature and pressure to which it is subjected. At atmospheric pressure, oxygen exists as a solid at temperatures below its melting point, –361°F (–218°C). Solid oxygen turns into a liquid at its melting point and remains in this state until the temperature rises to its boiling point, –297°F (–183°C). At this latter temperature, liquid oxygen vaporizes into the gaseous state. Conversely, gaseous oxygen will turn into liquid, at atmospheric pressure, by cooling to a temperature below –297°F. By increasing the pressure, gaseous oxygen can be liquefied at higher temperatures up to its critical temperature, –182°F (–119°C). Oxygen will not condense to a liquid at temperatures above its critical temperature regardless of the pressure applied. The pressure required to liquefy oxygen at its critical temperature is known as its critical pressure, 736.5 psia. The application of high-pressure and ultra-low temperatures to convert gases into their liquid state is known as the science and technology of cryogenics. Liquid oxygen is a cryogenic fluid.

1.2 PHYSICAL PROPERTIES OF OXYGEN.

Gaseous oxygen is colorless, odorless, tasteless and about 1.1 times as heavy as air. Liquid oxygen is an extremely cold, pale blue fluid, which flows like water. One gallon of liquid oxygen weighs 9.519 pounds which is approximately 1.14 times the weight of one gallon of water. (See Table 1-1.) Liquid oxygen is stored and handled at atmospheric pressure in well-insulated containers which maintain the liquid at its boiling point. Therefore, liquid oxygen is always boiling as it slowly turns into gaseous oxygen. As the expanding gas from the boiling liquid increases in amount, it builds up pressure within the container. Therefore, the expanding gas must be vented to the atmosphere, because confinement is both dangerous and impractical. When the cold and colorless gas is vented to the atmosphere, it produces a fog as it immediately condenses moisture and carbon dioxide in the air.

1.3 CHEMICAL PROPERTIES OF OXYGEN.

Oxygen is a very reactive material, combining with most of the chemical elements. The union of oxygen with another substance is known as oxidation. Extremely rapid or spontaneous oxidation is known as combustion. While oxygen is noncombustible in itself, it strongly supports and rapidly accelerates the combustion of all flammable materials; some to an explosive degree. Oxygen, as supplied, contains a minimum of 99.5% by volume of pure oxygen. The remaining 0.5% consists principally of argon, plus various organic and inorganic compounds in amounts measured in the parts per million range.

1.4 PRODUCTION (GENERATION) OF OXYGEN.

Air, the raw material for the production of oxygen is principally a mixture of 78.09% nitrogen, 20.95% oxygen and 0.93% argon, by volume. The remaining 0.03% consists of various gases, vapors, and particulate matter in varying concentrations, depending upon locality and climatic conditions. Air is compressed and cooled to liquefaction. The liquid oxygen in the liquefied air is separated by fractional distillation, whereupon it is withdrawn as liquid oxygen product or passed to a vaporizer for conversion to gaseous oxygen product. The equipment and facilities used in producing oxygen are known as liquid oxygen generating plants.

1.5 LIQUID OXYGEN GENERATING PLANTS.

Atmospheric air is passed through a liquid oxygen generating plant in five basic steps: compression, purification, refrigeration, expansion, and distillation. A brief description of the basic steps is as follows:

a. Air from the atmosphere is first passed through filters before undergoing compression in the air compressor and then is cooled by a heat exchanger.

b. The cooled compressed air is purified and dried by removal of carbon dioxide, hydrocarbons, solid particles, and moisture as it is passed through carbon dioxide scrubbers, filters, drying tubes, and hydrocarbon absorbers.

c. The cold and purified compressed air is further cooled by passage through a heat exchanger.

d. The air is then passed through an expansion valve where it liquefies as it becomes as cold as its temperature of liquefaction.

e. The liquid air is fed to the fractional distillation column where it flows through numerous trays, boiling off nitrogen and releasing liquid oxygen. The liquid oxygen collects at the bottom of the column, where it is drawn off as product or diverted to a vaporizer for conversion to gaseous oxygen product.

1.6 SUPPLY SOURCES OF OXYGEN.

Liquid and gaseous oxygen supplied to the Air Force are obtained from commercial and AF Operated (base) generating plants. These products must meet the requirements of the current issue of Specification MIL-PRF-27210.

1.7 CONTAMINANTS AND CONTAMINATION OF LIQUID OXYGEN.

Liquid oxygen as produced by generating plants contains contaminants which are not completely removed by the generating process. Atmospheric air, from which liquid oxygen is generated, is the primary source of contamination. An additional source of contamination is the compressors and other equipment of the generating plants. Airborne contaminants and those added by the generating plants are partially removed by a system of filters, absorbers, driers, and heat exchangers before the air is finally liquefied. When the liquid oxygen separates from the liquefied air, it carries with it those contaminants which are not completely removed. The variety and quality of contaminants which separate with the liquid oxygen depend on how effective their removal has been during the generating process. Generating plants are designed to remove contamination to the lowest limits possible both for safety of operation and for quality of product. These levels as well as the types and significance of contaminants are the basis for the procurement limits of the specification. A second level of quality described as use limits allows for sources of increasing contamination in liquid oxygen during storage, handling, and transfer.

1.8 TYPES AND SIGNIFICANCE OF CONTAMINANTS.

The types and significance of contaminants in liquid oxygen are described in Paragraph 1.9 through Paragraph 1.11.

1.9 HYDROCARBONS.

These contaminants are present in atmospheric air, and are also added by the compressors and other equipment of the generating plant. They are only partially removed by the low-temperature hydrocarbon absorption purifiers of the generating plants. Those which separate with the liquid oxygen are called light hydrocarbons because they contain four carbon atoms or less, such as methane, acetylene, ethane, ethylene, propane, and butane. Heavier hydrocarbons are removed to insignificant concentrations in properly operating plants. However, through mistakes, carelessness, or breakdown of equipment during storage, handling, and transfer of liquid oxygen, heavy hydrocarbons can cause contamination in the form of solvents, oils, greases, or fumes. The presence of hydrocarbons in liquid oxygen constitutes a potential fire and explosion hazard. The hazard increases during storage and handling because all of the common hydrocarbon contaminants are less volatile than liquid oxygen and therefore increase in concentration. If either the solubility limit or the lower flammability limit of a hydrocarbon is exceeded, the condition is especially hazardous. A source of ignition can initiate a fire or explosion if the hydrocarbon is present in sufficient concentration to sustain combustion. Ignition sources can be static electricity, mechanical, and fluid friction, and shock waves introduced by impact. Whenever a hydrocarbon is present in quantities greater than its solubility in liquid oxygen, it separates out of the liquid as a solid. Even the smallest grain of hydrocarbon solid in liquid oxygen has the potential of continued burning upon suitable ignition. Although one tiny particle may not be dangerous in itself, a collection of such particles could be serious, since ignition may propagate from particle to particle. Acetylene is especially hazardous in this respect.

a. Acetylene. Acetylene is the most hazardous hydrocarbon contaminant because it is very insoluble, it can readily be triggered into ignition, and because it is chemically unstable it can decompose under certain conditions and become its own source of ignition.

b. Significance in Aviators Liquid Breathing Oxygen (ABO). Hydrocarbon contaminants in liquid oxygen create, in addition to their potential fire and explosion hazards, potential psychological and physiological hazards to aircrews when liquid oxygen is used for breathing purposes. Depending upon the type and concentrations of hydrocarbons, psychologically, the effects may be uneasiness, apprehension, or possible panic, resulting from detecting their presence by odor; physiologically, the effects may be nausea, illness, intoxication, or possible asphyxia.

1.10 INERT SOLIDS.

These contaminants are classified as inert solids because they normally do not react with oxygen to create a fire and explosion hazard, and to distinguish them from hydrocarbons, which become solids when their solubility limits are exceeded. Inert solid contaminants in liquid oxygen are hazardous for a number of reasons. First, they may cause mechanical malfunctions or failures. Second, they may cause plugging of filters, lines, injectors, valves, etc. Third, they may accumulate charges of static electricity. Inert solids consist of three distinct forms:

a. Particulate Matter – these solids consist of rust, metal fragments, dust, and fibers derived from the equipment or the environment of the liquid oxygen supply system. These contaminants are solids at normal temperatures as well as at liquid oxygen temperature.

b. Moisture – in its liquid or vaporous form, moisture condenses to ice on contact with liquid oxygen or with the cold surfaces of equipment. Atmospheric moisture is an ever-present source of contamination.

c. Carbon Dioxide – this contaminant is slightly soluble in liquid oxygen but separates out of liquid oxygen as a solid when its solubility limit is exceeded.

1.11 TOXIC AND ODOROUS CONTAMINANTS.

The odorous and toxic characteristics of hydrocarbons have already been discussed in Paragraph 1.9. In addition to the hydrocarbons, there are other contaminants that, if present in aviator's liquid breathing oxygen, may also affect the mental and physical well being of aircrews. In particular, these contaminants are nitrous oxide and chlorinated hydrocarbons.

1.12 SOURCES OF INCREASING CONTAMINATION.

The initial contamination of liquid oxygen in the generating plant increases continuously after generation, as nonvolatile contaminants are concentrated by the evaporation of liquid oxygen. This gradual process of increasing contamination is accelerated if contaminants are introduced during storage, handling, and transfer operations, all of which are potential sources of increasing contamination. The added contaminants are concentrated as liquid oxygen vaporizes and the increasing contamination of the oxygen is therefore compounded each time contaminants are introduced. This means that the problem of controlling contaminants becomes more severe as the liquid oxygen passes through the aviator's breathing oxygen supply system. Thus, an acceptable concentration of contaminants in liquid oxygen as generated or procured can increase to a point which may threaten the safety or reliability of the mission. Therefore, the procurement limits were set low to allow for the normal increase in contamination during storage and use limits were set to define the upper bounds of usability. This margin of safety, however, should not be a reason to relax the guard against contamination of liquid oxygen.

1.13 INCREASING CONCENTRATION DUE TO EVAPORATION OF LIQUID OXYGEN.

Liquid oxygen in the supply system is always boiling and evaporating. Nonvolatile contaminants in liquid oxygen are always increasing in concentration as the amount of liquid decreases. This ever-present process of increasing contamination is intensified by cool-down vaporization losses associated with liquid transfer operations. Concentrations of the contaminants will increase in approximate proportions to the amount of liquid oxygen loss by vaporization. In the case of large scale transfers of propellant liquid oxygen, the increases of concentration of contaminants can be of considerable magnitude. For example, if a 10% vaporization loss occurs, the concentration of contaminants will automatically increase by a factor of 1.11. Obviously, repeated losses will increase contamination to dangerous levels.

1.14 HANDLING AND TRANSFER OPERATIONS.

These operations are a continuing source of increasing contamination by contaminant addition. The types of contaminants range from dust and dirt to moisture and carbon dioxide and other atmospheric constituents. Whenever transfer operations require the connection or disconnection of a transfer line, the opportunity for introducing additional contamination arises. At the time of connection, atmospheric contaminants or dust and dirt may be trapped in a section of the transfer line, to be carried into the supply system by the flowing liquid. At the time of disconnection, atmospheric contamination may become deposited inside the cold transfer equipment, ready to enter the rest of the system during the next transfer operation. Field and laboratory experiments have shown that strong convective currents are formed by the density difference between cold oxygen vapors and warm ambient air. As the cold, denser oxygen vapors flow out of the low points of cold transfer equipment, the warm, less dense air flows in at the high points, depositing moisture and other condensables in the form of frost. Both mechanisms of contamination can be controlled by strict adherence to proper procedures. The trapped portion of the atmosphere may be removed by adequate purging before transferring, and condensables may be prevented from entering cold transfer connections by allowing the connections to warm up before disconnecting. The making and breaking of transfer connections should be accomplished as quickly as careful handling will permit.

1.15 EQUIPMENT.

The sources of increasing contamination of liquid oxygen from equipment are variable both as to time and origin. Long-term deterioration of mechanical equipment must be expected. The moving parts of valves and pumps will wear and contribute to particulate contamination. Other sources of potential contamination are the solvents and solids which may remain from repair or cleaning operations.

1.16 CONTAMINANTS AND CONTAMINATION OF GASEOUS AVIATOR'S BREATHING OXYGEN.

Prior to acceptance by the Government, gaseous Aviator's Breathing Oxygen (ABO) and cylinders are inspected by government quality assurance representatives to determine compliance with contractual requirements. Tests which are required prior to shipment are preformed at the supplier's facility by supplier personnel under the surveillance of a government representative. Trace contaminants are analyzed at government laboratories at 45-day intervals. Once the quality of oxygen within a cylinder has been established, that quality will continue so long as a positive pressure is maintained within the cylinder under normal storage conditions. Consequently, retesting of the oxygen at periodic intervals during storage is not necessary.

1.17 PERIODIC SAMPLE.

Samples are taken periodically to assure that generating plants and storage systems are capable of supplying and maintaining good product. Small variations from procurement or use limits are not physiologically critical but are indicators that corrective action is needed. Test failures should not be viewed as a signal for drastic measures, but rather should be investigated to determine their cause and effect.

1.18 SAMPLING.

Sampling is required in order to obtain a small portion of a large quantity, and it is the most important operation in the analysis of oxygen. Great care should be exercised so the sample represents the composition of the storage container. The best analysis can be completely invalidated by poor sampling.

Table 1-1. Oxygen Weight-Volume Equivalents

Oxygen						
Mass		Liquid Volume at Boiling Point			Gas Volume at One Atmosphere and 70°F	
Grams	Pounds	Liters	Gallons	Cubic Feet	Liters	Cubic Feet
1.000	0.002205	0.0008766	0.0002316	0.00003096	0.7540	0.02663
453.6	1.000	0.3976	0.1050	0.01404	342.0	12.08
1141.0	2.515	1.000	0.2642	0.03532	860.11	30.38
4318.0	9.519	3.785	1.000	0.1337	3256.0	115.0
32300.0	71.21	28.32	7.481	1.000	254355.0	860.1
1.326	0.002924	0.001163	0.0003072	0.00004106	1.000	0.03532
37.55	0.08280	0.03292	0.008697	0.001163	28.32	1.000

CHAPTER 2
QUALITY CONTROL OF AVIATOR'S LIQUID BREATHING OXYGEN

2.1 INTRODUCTION.

During flight, aircrews rely on the quality of liquid aviators breathing oxygen for flight safety. The quality control of Aviators Breathing Oxygen (ABO) requires continuous surveillance to assure it is free of harmful contaminants on delivery to the aircraft. Surveillance begins with base generation or procurement and continues throughout storing, transferring and servicing to the aircraft. Each operation in the aircraft liquid oxygen supply system must be carried out in strict compliance with procedures established to assure safety of flight and mission completion.

2.2 SCOPE.

This section establishes procedures and requirements to assure the quality of ABO that is used by aircrews. It applies to base personnel who are responsible for supervising or performing the operations necessary to deliver ABO to aircraft.

2.3 PERSONNEL.

Personnel selected for assignment to the cryogenics element of the Fuels Management Flight shall be trained in order to develop a thorough knowledge of the characteristics of ABO, its contaminants, and the systems in which it is used. Reliable and knowledgeable personnel are the key to an effective quality control program.

2.4 CONTROL OF CONTAMINATION.

A knowledge and understanding of how contaminants are concentrated in liquid oxygen by the sources of increasing contamination are essential to the effective control of contamination. (See Paragraph 1.7.)

2.5 VAPORIZATION.

The concentration of contaminants due to liquid oxygen vaporization cannot, of course, be prevented. However, the rate of increasing contamination from this source shall be controlled by minimizing heat additions in handling and transfer through proficient and careful performance of operations.

2.6 EQUIPMENT.

Addition of contaminants from equipment shall be reduced or prevented by operating and maintaining generators, storage tanks, servicing trailers, and aircraft liquid oxygen systems according to applicable technical manuals.

2.7 HANDLING AND TRANSFER.

The addition of contaminants from the environment shall be prevented by careful and proficient handling and transfer operations. Liquid oxygen strongly attracts and absorbs atmospheric gases, some of which are odorous and which may be present in the atmosphere, due to an environmental source.

2.8 QUALITY CONTROL REQUIREMENTS OF AVIATOR'S LIQUID BREATHING OXYGEN.

2.8.1 Procurement Limits. ABO must meet the requirements of Specification MIL-PRF-27210. Procurement limits for odor, purity, moisture and minor constituents are contained in the specification and are shown in Table 2-1 of this technical order.

2.8.2 Use Limits.

See Table 2-1.

NOTE

> No use limit for purity is included because experience has shown that results of this test represent the condition of the sampler or the technique of sampling rather than the quality of the liquid breathing oxygen. The purity will be checked, however, and recommendations, including disposal of oxygen, will be made following the investigation of test results which repeatedly fall below a purity value of 99.5%.

These limits are for monitoring the condition of liquid breathing oxygen in the base storage tank and not each individual shipment. It is not desirable to hold the oxygen in a storage tank until an analysis is received from a laboratory since liquid oxygen is a perishable product and the contaminant level will increase on standing. When a storage tank has reached a contaminant level that exceeds the use limits in Table 2-1, corrective action will be taken to find the cause of this increased contamination level.

Table 2-1. Limits

	Procurement Production Limit	Use Limits
Odor	None	None
Purity Percent by vol	99.5 (Min)	No Limit – Report Only[1]
Carbon Dioxide (ppm by vol)	5 (Max)	10 (Max)
Methane (ppm by vol)	25 (Max)	50 (Max)
Acetylene (ppm by vol)	0.05 (Max)	0.1 (Max)
Ethylene (ppm by vol)	0.2 (Max)	0.4 (Max)
Ethane and higher hydrocarbons (ppm by vol)	3 (Max)	6 (Max)
Nitrous Oxide (ppm by vol)	2 (Max)	4 (Max)
Halogenated Compounds:		
Refrigerants (freons, etc.) (ppm by vol)[2]	1 (Max)	2 (Max)
Solvents (trichloroethylene, methyl, chloroform, etc.) (ppm by vol)	0.1 (Max)	0.2 (Max)
Others (ppm by vol)	0.1 (Max)	0.2 (Max)
Moisture (ppm by vol)	7 (Max)	Not Required

[1] Tank from which samples are less than 99.5% pure shall be resampled. Corrective action will be recommended by DET 3, WR-ALC/AFTT when samples repeatedly fall below 99.5%. See Paragraph 2.8.2.

[2] R-113 or 1, 1, 2-trichloro 1, 2, 2-trifluoroethane may be used as a refrigerant or a solvent. Regardless of application, the refrigerant limits shall apply.

2.8.3 Emergency Use Limits. Following guidance is provided concerning use of ABO under emergency conditions when disposal of liquid ABO containing more than use limit of each trace contaminant (except odor) creates aircraft mission problems.

a. Recommendation to use ABO can be given provided:

(1) Each contaminant content does not exceed two times the use limit.

(2) A sample is submitted immediately after resupply of base storage tank. Purpose of sample is to determine if high contaminant level is in product supplied or produced. If contaminant level is reduced significantly after resupply, continued use of product can be recommended. If contaminant level is not reduced, supply source must be sampled immediately and action taken to eliminate contamination at its source. Continued use from storage tank down to purging level is acceptable. At that point, tank should be purged.

b. When contamination is in a sample from an Air Force generator-receiver tank, immediate steps must be taken to improve performance of generating plant and to control product at procurement limits in Table 2-1. If contamination problems continue after plant operations are investigated, then consideration must be given to the location of plant or possibility of installing additional filters.

c. Authorization of emergency use limits will only be extended when action is being taken to assure that future supplies will improve in quality.

d. The analyzing laboratory will coordinate with DET 3, WR-ALC/AFTT in CONUS or Major Air Commands in overseas areas before authorization of emergency use limits can be granted. This authorization shall be included on the test report.

e. Authorization to use product which exceeds emergency use limits may be requested from AFTT. This authorization will be made only if use is acceptable to AFTT after consultation with Air Force Institute of Operational Health (AFIOH).

Table 2-2. Sampling and Testing Requirements[1]

Source	Test	Conditions	When Sampled	See Paragraph
Air Force Operated Generating Plants	Purity and Odor	1. Production run is longer than 24 hours 2. Otherwise	1. Every 24 hours 2. During each production run	2.16
	Minor Constituents	All	Every 45 days	2.16
Base Storage Tanks	Odor	1. Aircraft converters are serviced directly from storage 2. Otherwise	1. Before reservicing converters each day 2. When odor is detected in servicing trailer	2.17
	Purity, Odor and Minor Constituents	All	Every 90 days	2.17
Servicing Trailers	Odor	1. Filled more than once daily 2. Otherwise	1. After first filling each day 2. After each filling	2.22
Aircraft Converters	As Directed	All	After incidents affecting flying personnel	2.13 2.24

[1] These are minimum requirements. More frequent or additional tests may be deemed necessary after examination of pertinent conditions and facts.

2.9 SUPPLY SOURCES OF AVIATOR'S LIQUID BREATHING OXYGEN.

2.9.1 Commercial Generating Plants. Aviator's liquid breathing oxygen procured from commercial generating plants must meet the requirements of the current issue of Specification MIL-PRF-27210. To ensure this, it is necessary that inspection by a government Quality Assurance Representative (QAR) be performed at the filling plant. Generally, it is required that the ordering activity send two copies of the purchase order to the office designated by the Federal Directory of CAS Components at http://www.dcma.mil or other inspecting activity authorized by DET 3, WR-ALC/AFTT so that they may schedule inspections. When an overseas liquid oxygen generating plant is not operational and liquid oxygen must be procured from a commercial source while awaiting plant repair, cryogenics personnel (AFSC 2F0X1, SEI 037) assigned to the requesting organization's cryogenics section may perform QAR inspections.

2.9.2 Commercial Generating Plants — Bare Base Operations. Under conditions of deployment the above inspections may not be available. In this case, one of the options below must be used. They are presented in the order of preference:

a. A commercial source is selected that provides aviator's breathing oxygen to other NATO Air Force locations. With this option, the USAF supply activity must coordinate with their NATO counterpart to obtain certification to NATO STANAG 7106, the standardization agreement for liquid oxygen. The procurement limits of this STANAG are equivalent to those of Table 2-1.

b. With the second option, the essential part of the inspection at the commercial generating plants, the preproduction and periodic sampling required by MIL-PRF-27210, is performed. Because the commercial source may not have the required sampler, the USAF supply activity may need to provide assistance. An initial sample (preproduction) is drawn from a storage tank at the commercial source and every 45 days (periodic) thereafter during continued use. The samples are sent to the designated laboratory. See Paragraph 2.33. Once testing of the preproduction sample shows that the oxygen meets the requirements of the specification, product may be procured from the commercial source. If a periodic sample fails, procurement must stop until additional testing shows that the problem has been corrected. The preproduction and periodic inspection requirements including the procurement limits of MIL-PRF-27210 apply.

c. With the third option, the initial sample is taken from the commercial trailer and the liquid oxygen is unloaded into storage. Each tank receiving this product is placed in a hold status until the sample is tested and authorization to use it is received from the laboratory. This satisfies the initial sampling (preproduction) requirement. Trailers received after the initial authorization may be unloaded into storage and the liquid oxygen used as long as a commercial trailer is sampled every 45 days or less. This satisfies the periodic sampling requirement. The preproduction and periodic inspection requirements including the procurement limits of MIL-PRF-27210 apply.

d. With the final option, the trailer is unloaded into storage. Each tank receiving this product is placed in a hold status until a sample from it is tested and authorization to use it is received from the laboratory. The Use Limits of Table 2-1 apply.

For each of the options, the commercial source must be required to sample and test each shipment for odor, purity, and moisture according to MIL-PRF-27210 or STANAG 7106, and provide the results of these tests along with the shipment. It should be noted that the option selected may be changed. If the conditions improve, then a higher option should be chosen; if they degrade, then a lower one should be chosen.

2.9.3 Air Force Generating Plants. Aviator's liquid breathing oxygen produced by generating plants must meet the requirements of the current issue of Specification MIL-PRF-27210.

2.10 SAMPLING AND TESTING.

Sampling and testing at intervals and points in the supply system provides the continuous monitoring of contamination that is essential to the quality control of aviator's liquid breathing oxygen. Tests, both singly and collectively, serve many needs and purposes; in fact, they are the basis for the performance of all operations in supply. No operation in supply shall be performed until a basis for action is established by tests.

2.11 ON-BASE TESTING.

Air Force Bases which produce liquid oxygen from on-base generating plants shall sample and test generated product in accordance with Paragraph 2.16. Continuous surveillance of storage tanks, servicing trailers, and aircraft converter systems for the presence of odor shall be made by the test for odor.

a. Odor Test – a liquid sample shall be tested for odor by pouring approximately 200 ml of the sample into a clean 400-ml beaker or similar container after covering the bottom of the beaker with a clean, dry filter paper or other absorbant paper. A watchglass or some other means of partially covering the top of the beaker shall be used. This will prevent atmospheric constituents from being absorbed by the exposed liquid. The liquid shall be permitted to evaporate to dryness and warm up to approximately room temperature in an area free from air currents or extraneous odors. When the liquid has completely evaporated, the watchglass shall be removed and the beaker contents smelled at frequent intervals until the accumulated frost on the outside of the beaker has completely melted. Odors will be most prevalent when the beaker has warmed to nearly room temperature.

NOTE

The following test is required only when contamination with particulates is suspected.

b. Particulate Test – pour 200 ml of the sample into a clean 400-ml beaker or similar container, without a filter paper in the bottom. A watchglass or some other means of partially covering the top of the beaker shall be used. When the frost on the outside of the beaker has melted, the outside of the beaker shall be wiped with a clean, dry cloth and the beaker placed on a clean white paper. The interior of the beaker shall be visually examined, without the aid of magnification for the presence of particles. Liquid oxygen shall contain no particles with any dimension larger than 1000 micrometers (0.039 inch) or fiber longer than 6000 micrometers (0.234 inch) and maximum cross-section of 40 micrometers (0.00156 inch).

c. Cleaning of Beakers – beakers used for the odor or particulate test shall not be used for any other purpose. This should prevent them from becoming contaminated with some substance which is difficult to remove by ordinary cleaning methods. A laboratory glassware washer with rinse cycles which include distilled or demineralized water may be used. The following procedure is also acceptable.

(1) Clean by brushing in warm tap water with detergent.

(2) Rinse with warm tap water.

(3) Rinse three times with distilled or demineralized water.

(4) Support in an inverted position for room air drying or place in an oven to dry.

(5) Store in an inverted position or keep covered to prevent contamination.

2.12 PERIODIC OR REQUESTED TESTS FOR PURITY, KINDS, AND AMOUNTS OF CONTAMINANTS.

Tests shall be performed by the laboratories listed in Table 2-4. Other laboratories must be approved by DET 3, WR-ALC/AFTT or, in overseas areas, by Command Headquarters prior to use. All laboratories performing ABO analysis will participate in Air Force ABO correlation program conducted by DET 3, WR-ALC/AFTT. All analysis of ABO shall be performed according to procedures in MIL-PRF-27210 and MIL-STD-1564 unless approval is given by DET 3, WR-ALC/AFTT to use other procedures.

2.13 TESTS AFTER INCIDENTS AFFECTING FLYING PERSONNEL.

Samples taken after incidents in which flying personnel are affected, and any additional samples deemed necessary by the Director of Base Medical Services, will be submitted through the Base Medical Service to one of the laboratories listed in Paragraph 2.33 and Table 2-4. Other laboratories may be approved by USAF Clinic and DET 3, WR-ALC/AFTT.

a. The base organization responsible for taking samples shall notify DET 3, WR-ALC/AFTT by message/e-mail that a sample has been submitted. The date, method of shipment, and sample identification number shall be provided.

b. Taking samples from an aircraft oxygen system after an incident requires cooperation between the Base Fuels Management Office and the Aircraft Maintenance Office that normally maintains the oxygen system. The Base Medical Services shall not be required to take the sample from the aircraft system.

c. The Base Fuels Management Office shall provide a liquid oxygen or cryogenic sampler for taking samples after incidents.

d. Take samples from aircraft oxygen systems in accordance with Paragraph 2.24 or T.O. 33D2-10-60-1.

e. The laboratory shall provide a copy of their analysis to DET 3, WR-ALC/AFTT.

2.14 RECEIPT OF AVIATOR'S LIQUID BREATHING OXYGEN FROM A CONTRACTOR.

Before unloading is permitted, check the DD Form 250 to ensure that inspection has been accomplished (Paragraph 2.9.1). A signature of the QAR or Alternative Release Procedure note is required.

2.15 RECEIPT OF AVIATOR'S LIQUID BREATHING OXYGEN FROM A CONTRACTOR BARE BASE OPERATIONS.

When using the alternate inspection procedures described in Paragraph 2.9.2, check the invoice and/or test report to ensure that it contains results for the odor, purity, and moisture tests and to ensure that the results meet the requirements of Table 2-1 before unloading is permitted.

2.16 AIR FORCE GENERATING PLANTS.

Liquid oxygen produced from Air Force generating plants shall be sampled and tested as follows:

a. Sampling Location – liquid product line.

b. Tests and Frequencies:

(1) Test for odor and purity during each production run. If a production run is longer than 24 hours in duration, test for odor and purity every 24 hours.

(2) Send a sample to a designated laboratory (Paragraph 2.12) for analysis of minor constituents and moisture in accordance with Specification MIL-PRF-27210 once every 45 days and whenever contamination is suspected. Identify sample by completing applicable blocks of AFTO Form 176 and attaching it to the sampler.

c. Quality Control Requirements – test results shall conform to the procurement limits in Table 2-1. When results of testing performed in accordance with (1) and (2) above indicate that a plant is not generating product which meets the procurement limits, generation of product for use as Aviator's Breathing Oxygen shall be discontinued until product quality is improved and the product meets the requirements specified herein.

2.17 BASE STORAGE TANKS — SAMPLING/TESTING.

Sample and test the base storage tanks as follows:

a. Sampling Location – service line.

b. Test and Frequencies:

(1) Odor.

(a) Test for odor if any cart filled from storage contains an odor.

(b) Test for odor once daily if aircraft converters are serviced directly from storage tanks or Multiple Servicing Unit (MSU). This test shall be performed before converters are serviced.

(2) Purity, Odor, and Minor Constituents – once every 90 days and whenever contamination is suspected, a sample of the contents of base storage tanks shall be sent to a designated laboratory (Paragraph 2.12). Upon receipt at the laboratory, the sample shall be tested for use limits. Identify sample by completing AFTO Form 176 and attaching it to the sampler (omit procurement data).

c. Quality Control Requirements – test results shall conform to the use limits in Table 2-1. When results of testing performed in accordance with (1) and (2) above indicate that contents exceed the use limits, the contents of the tank represented by the sample shall be drained and the tanks purged in accordance with the applicable storage tank operation and service technical manual. See Paragraph 2.8.3 for emergency use limits.

2.18 BASE STORAGE TANKS – RECLAMATION OF LIQUID OXYGEN CONTAMINATED BY MOISTURE AND CARBON DIOXIDE (CO_2).

In areas which have recurring moisture and CO_2 contamination, the liquid oxygen may be put through a locally manufactured molecular sieve filter. The Major Air Force Command will determine if it is cost effective to build a filter to remove the moisture and CO_2 for reclaiming the liquid oxygen. The following is a description of a filter which may be used: The molecular sieve filter consists of two stainless steel cylinders, 4 feet long and 6 inches in diameter arranged in a U shape. The cylinders are connected in series by 1-inch piping with cryogenic fitting used as a union to allow use of a single cylinder. A safety disc is installed on each cylinder. Sixty mesh screens are used on each end to retain the molecular sieve. The two cylinders contain approximately 50 pounds of Grade 544 Molecular Sieve material, Type 13X, pellet size 1/16", 8 – 12 mesh. The assembly is bolted onto a cart with wheels.

2.19 BASE STORAGE TANKS — TRANSFER OF LIQUID OXYGEN TO OFF-BASE TANKS.

When transferring and shipping liquid oxygen from base storage to off-base activities, a margin of quality should be allowed. Liquid oxygen should not be shipped if it is near use limits because of its degradable nature and the likelihood that the quality of the liquid will deteriorate beyond use limits during the transfer and shipping operation.

2.20 BASE STORAGE TANKS — NONAVAILABILITY OF SAMPLER.

Occasionally a sampler is not available for sampling liquid oxygen. Every effort should be made to obtain one. While awaiting a sampler, tanks may be used without sampling if they are purged once every six months according to procedures described in the applicable technical manuals for their operation and maintenance.

a. Product from tanks affected by this paragraph shall not be transferred to other storage tanks.

b. Product remaining in the tank at the end of the 6-month cycle is not suitable for use except when requalified by sampling and testing.

2.21 BASE STORAGE TANKS — EMPTY.

Base storage tanks shall be purged in accordance with applicable operation and service technical manuals when both of the following conditions occur:

a. The tank has become empty due to evaporation of contents.

b. The tank has warmed to ambient temperature.

2.22 SERVICING TRAILERS.

a. Sampling/Testing – the organization responsible for filling aircraft liquid oxygen servicing trailers will sample and test each unit as follows:

(1) Sampling Location – at the fill/drain port.

(2) Test and Frequency – test for odor in accordance with Paragraph 2.23 and Paragraph 2.11, Step a immediately after first filling each day.

(3) Quality Control Requirements – odor – none.

(4) Odor Test Failure – when tests show the presence of odor in the contents of a servicing trailer, the contents shall be drained and the trailer purged in accordance with the applicable operation and service technical manual. Purging shall be recorded in the remarks column of the AFTO Form 134. The storage tank which was used to fill the trailer shall also be sampled for odor.

NOTE

Procedures to prepare trailers for standby status may be found in the applicable operation and service technical manual. See the subsection on preservation for storage and/or shipment in those manuals.

b. Low Use Trailers – it is advisable to keep trailers containing liquid oxygen to a minimum. Those trailers not required for current levels of operation should be maintained in standby status. There are two reasons for this. First, the low use which results when too many trailers contain liquid oxygen may allow contaminants to increase to unacceptable levels due to selective evaporation of oxygen (see Paragraph 1.13). Second, servicing trailers have higher evaporation rates than storage tanks and, as a result, are less efficient storage containers. Thus, the above affects both quality control and cryogenics conservation. The following criteria are provided for those organizations who must employ low use trailers:

(1) Definition – a low use trailer is one which was used to service aircraft on less than 5 of the past 12 calendar days.

(2) When to Fill a Low Use Trailer – a low use trailer shall be filled before servicing aircraft if it was not filled during the past two calendar days.

(3) When to Drain and Fill a Low Use Trailer – a low use trailer shall be drained and filled before servicing aircraft if it was not drained during the past 12 calendar days. Exception: If a trailer has been filled with 45 gallons or more on one of the 12 days, it may be considered drained and filled.

Data on trailer draining and use for servicing may be obtained from the AFTO Form 134. The organization responsible for servicing the aircraft shall drain the trailers when required and shall record this action in the remarks column of the AFTO Form 134.

c. The contents of liquid oxygen servicing trailers shall not be returned to base storage.

d. Liquid oxygen servicing trailers shall be purged in accordance with the applicable operation and service technical manual when both of the following conditions occur:

1. The trailer has become empty due to evaporation of contents.

2. The trailer has warmed to ambient temperatures.

e. AFTO Form 134 shall be maintained on liquid oxygen servicing trailers. Below are instructions for filling out this form which records two distinct operations – filling trailers and servicing aircraft. The entries for each operation shall be made on separate rows of the form and shall be initialed by an individual of the organization performing the operation.

(1) The organization making the initial entry on the form shall enter trailer serial number in appropriate block.

(2) The organization filling the trailer shall enter the following:

a. Filling Date

b. Storage Tank Number from Which Trailer Was Filled

c. Results of Odor Test (Pass/Fail) if Required – See Step a (2) above.

(3) The organization servicing the aircraft shall enter the following:

a. Serial Number or Tail Number of the Aircraft or Aircraft Converter Serviced. It is preferred that the aircraft number be listed in column G; however, where converters are removed from aircraft for servicing this may be impractical. In those instances, the converter number may be used.

b. Servicing Date

NOTE

Quantity columns of AFTO Form 134 may be used for accountability or other purposes.

f. The organization servicing the aircraft shall maintain the file of AFTO Form 134. This file may be maintained on the servicing trailer. Forms may be destroyed two weeks after the date of the last recorded aircraft servicing.

2.23 SAMPLING PROCEDURE FOR SERVICING TRAILERS — ODOR TEST.

a. Assure that all aspects of ground safety are considered and that protective clothing is worn in accordance with T.O. 00-25-172.

b. Place drip pan under fill/drain port of servicing trailer.

c. Remove dust cap from fill/drain port.

d. Hold 400-ml beaker under the fill/drain port in an upright position. Beaker tongs, Fisher Scientific P/N 02-620 or equivalent, may be used to do this. The beaker shall be prepared in accordance with Paragraph 2.11, Step c.

e. Position valves to allow gravity drain in accordance with the T.O. of the servicing trailer to be sampled. The fill/drain valve shall be opened slowly to allow a gentle flow from the fill/drain port.

f. Allow liquid oxygen to flow until beaker is approximately half full.

g. Close fill/drain valve.

h. Return all valves to liquid storage positions.

i. Replace dust cap.

j. Perform odor test in accordance with Paragraph 2.11, Step a.

2.24 AIRCRAFT CONVERTER SYSTEM.

Sample, test, and purge the aircraft liquid oxygen converter system as follows:

a. Sampling Location – at the drain valve.

b. Tests and Frequencies – test for odor in accordance with Paragraph 2.11, Step a and obtain any additional samples deemed necessary by the Director of Base Medical Service (Paragraph 2.13).

(1) As soon as possible after report of in-flight odors or incident by aircrews.

(2) In accordance with applicable aircraft manuals, T.O. 33D2-10-60-1 and/or Paragraph 2.25.

c. Purging Methods and Frequencies – in accordance with applicable technical manuals.

2.25 SAMPLING AIRCRAFT CONVERTERS.

See T.O. 33D2-10-60-1 for procedures to sample aircraft converters containing 15 liters or more of liquid oxygen. Use procedure below for converters containing less than 15.

a. Place drip pan under liquid oxygen servicing trailer outlet and aircraft vent to prevent liquid oxygen from contacting any oil or grease on the ramp.

b. Position liquid oxygen servicing trailer in close proximity to aircraft and remove filler valve access door on aircraft.

c. Remove liquid oxygen filler line from liquid oxygen servicing trailer.

d. Adapt sampler fill hose to liquid oxygen servicing trailer.

e. Unscrew protective caps from interconnection parts of both charging manifold assembly and cylinder assembly.

f. Ensure that sealing ring is in place on attachment port of charging manifold assembly.

CAUTION

Failure to follow the tightening procedure below may damage threads.

g. Invert cylinder assembly and attach to top of charging manifold assembly. Initially install and tighten cylinder assembly to charging manifold assembly by hand. Complete tightening operations utilizing a wrench.

h. Remove caps from sample inlet and outlet port of charging manifold assembly.

i. Open sampling valve on charging manifold.

j. Slowly open sample extraction valve on sample cylinder and allow precharge to purge sampler.

k. When precharge is depleted, do not close sample extraction valve on sample cylinder. This valve is left open.

l. Close sampling valve on charging manifold.

WARNING

Protective clothing will be worn throughout the sampling operation.

m. Connect sampler fill hose with adapter to liquid oxygen servicing trailer.

n. Build up pressure in the servicing trailer to 30 psig and purge hose by opening liquid service valve. When hose is purged, close liquid service valve. Connect fill hose to charging manifold assembly inlet.

o. Open oxygen supply valve on servicing trailer.

p. Allow oxygen to flow through the cryogenic sampler until a strong stream of liquid emerges from the outlet port.

q. Allow stream of liquid oxygen to flow for approximately two minutes, then close servicing trailer supply valve.

r. Connect sampler fill hose with adapter to aircraft liquid oxygen outlet. Slowly open valve on aircraft outlet to allow the liquid oxygen to flow through hose into charging manifold and out through outlet fitting. Allow flow to increase until there is a steady flow of oxygen (not necessarily liquid oxygen). Open the sampling valve on the cryogenic sampler. Do not wait for the steady flow of liquid oxygen before opening the sampling valve on the sampler. Leave the sampling valve open until the aircraft system pressure begins to decrease rapidly or until a steady flow of liquid appears. Close the sampling valve on the cryogenic sampler immediately.

s. Close outlet valve on aircraft.

t. After liquid stops flowing from outlet port disconnect sampler fill hose from aircraft and charging manifold.

WARNING

When inverting charging manifold and cylinder assembly, residual liquid oxygen may spill from the charging manifold inlet and outlet. Care will be taken to avoid contact of the liquid oxygen with skin and splashing cryogenic liquid in eyes. Protective clothing will be worn when performing this task.

u. Invert charging manifold assembly and cylinder assembly and place attached assembly in the cylinder assembly cavity of the case.

CAUTION

If sampler inlet valve on charging manifold is not opened before disconnecting the sample cylinder, the trapped pressure will blow out the sealing ring on attachment port.

v. Observe pressure gauge on cylinder, when pressure has stabilized after approximately 20 minutes close sample extraction valve on cylinder. Open sampler inlet valve or charging manifold to vent pressure from charging manifold. After this pressure is vented, disconnect cylinder from charging manifold.

NOTE

There is no minimum pressure limit to obtain in the sample cylinder when sampling from an aircraft.

w. Replace all protective caps and close inlet valve on charging manifold.

2.26 TESTING AND SAMPLING EQUIPMENT.

See Table 2-3.

2.27 SAMPLER PREPARATION.

Samplers which have been repaired or hydrostatically tested may contain contaminant gases such as nitrogen or solvent vapors. If a sampler is used when in this condition, test results will fail to be within use limits. This failure will be due to the condition of the sampler rather than the quality of the oxygen sampled. To prevent such failures, purge each sampler which has been repaired before use. Use oxygen as the purging gas. See the technical manual for the sampler for purging procedures. If gaseous oxygen is not available, a sampler may be purged by taking a sample, allowing the pressure to stabilize, and then discharging the sample. Repeat this process two additional times. As an additional precaution, especially when a solvent has been used, the sampler may be sent to a designated laboratory to find out if the sampler has been purged enough to use for sampling. If this is to be done, pressurize the sampler according to the purging procedures of the sampler manual. These steps may prevent storage tanks from being placed in a hold status unnecessarily.

Table 2-3. Testing and Sampling Equipment

Item No.	NSN No. and Part No.	Nomenclature
1	6640-01-329-7539	Laboratory Beaker, 400ml, Type 1
2	6640-00-290-6789	Watchglass, Class A, 4-inch (100mm) diameter
3	6640-00-290-5776	Filter Paper, Type I, Class 2, 5.5cm disc
4	6695-01-101-5691, P/N 600646, MIL-S-27626, TTU-131/E	Cryogenic Sampler

2.28 SAMPLE IDENTIFICATION.

NOTE

Every precaution must be taken to completely identify each sample to prevent errors in identifying samples during handling, testing, reporting, and recording test results. Samples which are not identified as required by this T.O. will not be tested by the laboratory until complete identification has been accomplished.

Each sample will be identified with an AFTO Form 176 bearing the following information.

2.28.1 Front Side — Top Section. This section is to be completed for all samples.

- Item – Type and grade of Oxygen
- Sampler No. – Serial number of sampler
- Specification – Enter applicable Specification MIL-PRF-27210
- Submitted by – Name, address, and phone number of activity submitting the sample
- Reason for Analysis – Check appropriate square

2.28.2 Front Side — Procurement Section. This section is to be completed for samples taken from contractor storage tanks. It applies to those activities who have been authorized to perform QAR responsibilities by this technical manual or by DET 3, WR-ALC/AFTT. See Paragraph 2.9.1.

- Contractor – Enter name of contractor
- Location of Facility – Enter city and state or city and country
- Contract No. – Enter contract number
- Date Sampled – Enter the date that the sample was taken
- Sample No. – Enter the number given to the sample (A number must be given to each sample by the submitting activity for use in identifying it. Samples should be numbered in consecutive order during a calendar year. For example, in 1994, the first sample should be 94-1, the second should be 94-2, and so on.)
- Pressure of Sampler as Submitted – Enter the pressure of the sampler prior to being put into the transportation system

2.28.3 Back Side — Base Storage Section. This section is to be completed for samples taken from base storage tanks.

- Storage Tank No. – The number used to identify the storage tank
- Date of Last Addition – Date of last delivery by supplier
- Supplier – Enter the name of the supplier and the city and state or the city and country from which the Oxygen was shipped
- Base Sample No. – Enter the number given to the sample (See the numbering method given above.)
- Date Sampled – Enter the date that the sample was taken
- Pressure of Sampler as Submitted – Enter the pressure of the sampler prior to being put into the transportation system

2.28.4 Back Side — Base Generation Section. This section is to be completed for samples taken from the liquid product line of oxygen generating plants.

- Plant No. – Enter the number given to the Oxygen generating plant
- Base Sample No. – Enter the number given to the sample (See the numbering method given above.)
- Date Sampled – Enter the date that the sample was taken
- Pressure of Sampler as Submitted – Enter the pressure of the sampler prior to being put into the transportation system

2.29 SAMPLER SHIPMENT.

a. To ensure timely arrival of samples at the laboratory, the Traffic Management Office (TMO) shall be requested to prepare required forms for shipment. Recommend that the appropriate priority and Required Delivery Date (RDD) for shipment available to the shipping activity be assigned. As a minimum, an Issue Priority Designator (IPD) 03/Transportation Priority (TP) 1 is authorized for shipment to Aerospace Fuels Laboratories. The submitting activity may assign a higher priority when circumstances warrant it. The submitting activity shall coordinate with the TMO to ensure that an appropriate priority is assigned and that everything is in order for expeditious shipment of the samples.

b. The proper shipping name for the filled sampler is OXYGEN or OXYGEN, COMPRESSED.

2.30 TEST REPORTS.

All Air Force laboratories testing Aviator's Breathing Oxygen shall provide results of analysis as follows:

a. Notify the submitting activity by telephone within 24 hours following completion of analysis when test results exceed use limits.

b. Complete a test report for each sample analyzed. An AFTO Form 213 can be used for this. This shall include transfer of all data provided on the AFTO Form 176.

c. Retain one copy of the test report for their files and submit one copy to each of the following: The submitting activity; DET 3, WR-ALC/AFTT, 2430

C St, Bldg 70, Area B, Wright-Patterson AFB, OH 45433-7632; Major Air Command, if laboratory is in overseas area; and other laboratories as requested.

2.31 USE OF TEST DATA.

a. The test data furnished by the laboratories will be used to determine if the oxygen is usable and to determine what action should be taken with respect to deteriorated oxygen. Deteriorated oxygen may be blended with new material to permit its use or it may have to be destroyed depending on the condition of the material. The specific action must be determined after examination of all pertinent conditions and facts. DET 3, WR-ALC/AFTT will provide assistance, upon request, with respect to action to be taken on deteriorated oxygen.

b. If test data indicates that Aviator's Breathing Oxygen with excessive contamination has been shipped from a commercial generating plant, DET 3, WR-ALC/AFTT will advise and recommend appropriate action to activities receiving product from that plant.

2.32 AIR FORCE INSTITUTE FOR OPERATIONAL HEALTH (AFIOH).

The AFIOH laboratory at Brooks City Base will provide guidance on oxygen contaminants that are not specifically addressed in this document. It is the responsibility of AFTT to contact and coordinate the disposition instructions with AFIOH for those samples that contain unusual contaminants.

AFIOH/SDCO
2402 E Dr
Brooks City Base TX 78235-5114

Telephone Numbers:
Commercial: (210) 536-6176 or 6177
DSN: 240-6176 or 6177

2.33 LABORATORIES.

Samples, except incident samples, shall be sent to a laboratory listed in Table 2-4 which is selected in this manner. Find the location of the submitting activity in Table 2-5 and note the number to the right of it. Find this number in Table 2-4 and the designated laboratory for the activity will be listed to the right along with addresses and telephone numbers. If the location of an activity is not listed, a request should be submitted to DET 3, WR-ALC/AFTT, 2430 C St, Bldg 70, Area B, Wright-Patterson AFB, OH 45433-7632, DSN: 785-8050, for a laboratory designation. Incident samples may be sent from any location to any laboratory listed in this chapter.

Table 2-4. Air Force Testing Laboratories

#	Shipping Address	Mail Address	Telephone Numbers
1	Aerospace Fuels Laboratory (FP2070) DET 3, WR-ALC/AFTLA 2430 C St, Bldg 70, Area B Wright-Patterson AFB, OH 45433-7632	Aerospace Fuels Laboratory DET 3, WR-ALC/AFTLA 2430 C St, Bldg 70, Area B Wright-Patterson AFB, OH 45433-7632	Commercial: (937) 255-2106 DSN: 785-2106
2	Aerospace Fuels Laboratory (FP2071) OL DET 3, WR-ALC/AFTLB Trundy Rd., Bldg 14 Searsport, ME 04974-0408	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLB P.O. Box 408 Searsport, ME 04974-0408	Commercial: (207) 548-2451
3	Aerospace Fuels Laboratory (FP2075) OL DET 3, WR-ALC/AFTLE 1747 Utah Ave., Bldg 6670 Vandenberg AFB, CA 93437-5220	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLE 1747 Utah Ave., Bldg 6670 Vandenberg AFB, CA 93437-5220	Commercial: (805) 606-6263 DSN: 276-2756
4	Aerospace Fuels Laboratory (FP2080) OL DET 3, WR-ALC/AFTLF – Bldg 725 Unit 5025 RAF Mildenhall, UK APO AE 09459	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLF Unit 5025 APO AE 09459-5025	Commercial: 44-1-638-54-2043 DSN: 314-238-2043/2797/5757
5	Aerospace Fuels Laboratory (FP2083) OL DET 3, WR-ALC/AFTLG – Bldg 854 Unit 5161 Kadena AB, Okinawa, JA APO AP 96368-5162	Aerospace Fuels Laboratory OL DET 3, WR-ALC/AFTLG Unit 5161 APO AP 96368-5162	Commercial: 011-81-611-734-1602/3394/0322 DSN: 315-634-3394/1602/0322
6	OC-ALC/TIELA Attn: Chemical Sciences Section 3001 Staff Drive/STE I-63 Tinker AFB, OK 73145-3038	OC-ALC/TIELA Attn: Chemical Sciences Section 3001 Staff Drive/STE I-63 Tinker AFB, OK 73145-3038	Commercial: (405) 736-2135 DSN: 336-2135

Table 2-5. Laboratory Designations

Location	#	Location	#	Location	#	Location	#
Africa	4	Iceland	2	Missouri	1 or 6	Panama	1
Alabama	1	Idaho	3	Montana	3	Pennsylvania	1
Alaska	3	Illinois	1	Nebraska	1 or 6	Rhode Island	2
Arizona	3	Indiana	1	Nevada	3	South Carolina	1
Arkansas	1 or 6	Iowa	1	Netherlands	4	South Dakota	1
Azores	2	Italy	4	New Hampshire	2	Spain	4
Belgium	4	Kansas	1 or 6	New Jersey	2	Tennessee	1
California	3	Kentucky	1	New Mexico	3	Texas	1
Colorado	3	Louisiana	1	New York	2	United Kingdom	4
Connecticut	2	Maine	2	North Carolina	1	Utah	3
Crete	4	Maryland	1	North Dakota	3	Vermont	2
Delaware	1	Mid-East	4	Norway	4	Virginia	1
Florida	1	Massachusetts	2	Ohio	1	Washington	3
Georgia	1	Michigan	1	Oklahoma	1 or 6	West Virginia	1
Germany	4	Minnesota	1	Oregon	3	Wisconsin	1
Greece	4	Mississippi	1	Pacific	5	Wyoming	3
Greenland	2						

CHAPTER 3
HAZARDS AND SAFETY PRECAUTIONS IN HANDLING LIQUID OXYGEN

3.1 GENERAL.

The potential hazards of liquid oxygen in the supply system are due to its characteristics which can cause: fire and explosions due to support and rapid combustion of all flammable material; high pressures, arising from confinement; and personal injury and equipment failure from extreme coldness.

3.2 SCOPE.

This chapter provides general procedures and requirements for the safe handling of liquid oxygen in the supply system. Refer to storage tank and servicing trailer manuals, aircraft -2 handbooks, and T.O. 00-25-172, for specific instructions.

3.3 PERSONNEL AND RESPONSIBILITIES.

It is the direct responsibility of all supervisors to assure that proper safety measures exist and are in effect, and that each person is thoroughly instructed in the hazards of liquid and/or gaseous oxygen and the necessary safety precautions for the work assigned.

3.4 FIRE AND EXPLOSION.

3.4.1 Hazards. Liquid oxygen supports and rapidly accelerates the combustion of all flammable materials to an explosive degree. Liquid oxygen, as generated, contains flammable hydrocarbon contaminants, which increase in concentration as liquid oxygen evaporates, or which may be increased by additional contamination during storage, handling, and transfer to hazardous levels. Liquid oxygen may react violently in contact with combustible vapors or solids under suitable conditions of temperature and pressure, and in the presence of a source of ignition such as static electricity, flames, sparks, and shock waves from impact. Some of the commonly known materials which may cause a fire or explosion in contact with liquid oxygen are: oil, grease, solvents, tars, asphalt, gasoline, kerosene, alcohol, acetone, propane, butane, wood, cloth, paper, cork, cotton, and paint.

3.4.2 Safety Precautions.

a. Minimize liquid oxygen evaporation and prevent additions of contaminants by proficient and careful performance of operations.

b. Do not smoke or permit others to smoke in prohibited areas.

c. Do not carry sources of flames and sparks, such as matches or lighters, and tobacco in any form into liquid oxygen handling areas.

d. Properly ground and bond storage tanks, semi-trailers, servicing trailers, and all other equipment involved in transfer operations to discharge dangerous accumulations of static electricity.

e. Keep work area, equipment, tools, and clothing free from oil, grease, or any other combustible material.

f. Avoid spilling liquid oxygen. In case of excessive spillage, the area will be immediately evacuated.

g. In the event liquid oxygen is spilled on clothing, immediately remove clothing. Always keep in mind that clothing absorbs liquid oxygen quickly, and often releases it slowly. An accidental spark or flame can cause clothes to burn with extreme rapidity.

h. The LAY-OF-THE-LAND shall always be checked before venting liquid oxygen. Heavy concentrations of vented oxygen gas shall not be allowed to drift towards motorized equipment, low places in the area, water drains, smoking areas, etc.

i. Extinguish immediately fires which are close to equipment containing liquid oxygen. Use normal firefighting methods. Any flow of liquid oxygen must be stopped by closing valves, if possible. Divert free-flowing liquid oxygen away from combustible materials with a strong stream of water.

j. A drip pan or other suitable container shall be placed under outlet (over-flow) vents of aircraft being serviced with liquid oxygen. This precaution shall be taken to prevent contact of possible spillage with any oil, grease, or other organic material which may be on the ramp.

3.5 HIGH PRESSURES FROM CONFINEMENT.

3.5.1 Hazard. Liquid oxygen is constantly evaporating as it turns into gaseous oxygen. If the gas, which expands and increases in amount, is confined, explosive pressures will be created.

3.5.2 Safety Precautions.

a. Never confine liquid oxygen in or to a given space.

b. Do not leave liquid oxygen in a closed container or trapped in a line between two valves, always open a valve on one end to avoid pressure build-up.

c. Check relief valves periodically to assure that they are in proper operating condition.

3.6 EXTREMELY COLD TEMPERATURES.

3.6.1 Hazard. The extremely cold temperature of liquid oxygen presents a dangerous hazard to personnel. It can freeze or seriously damage human tissue upon contact. The effect is similar to that caused by frostbite or thermal burn and, since liquid oxygen is about 395° below body temperature, the effect is instantaneous. Uninsulated parts of equipment are cooled to extremely low temperatures by liquid oxygen, and may freeze to the skin upon contact. Flesh can be badly burned, or can be severely torn in an attempt to free it. Since the immediate removal of skin surface from contact with cold equipment is essential, no time should be lost in pulling free from this contact.

3.6.2 Safety Precautions.

a. All personnel working with liquid oxygen shall wear personnel safety equipment.

b. Do not handle with bare hands any equipment in which liquid oxygen is contained, or through which it is flowing. Wear protective gloves at all times.

3.7 FIRST AID.

WARNING

Do not attempt to rewarm frozen parts until under proper medical care. Control of shock and pain and re-warming of frozen parts must be provided by medical service.

Remove from exposure immediately. Transport patient to emergency room of hospital/clinic as soon as possible identifying the exposure to liquid oxygen. Keep dry and warm with blankets en route to emergency room.

a. Blankets made of wool, wool blends, or fire blankets shall not be used. These blankets could generate sparks from static electricity.

b. Materials made of 100% cotton are recommended.

3.8 PERSONNEL SAFETY EQUIPMENT.

See T.O. 00-25-172.

CHAPTER 4
QUALITY CONTROL OF AVIATOR'S GASEOUS BREATHING OXYGEN

4.1 INTRODUCTION.

The quality control of aviator's gaseous breathing oxygen requires continuous surveillance. Surveillance begins with procurement or Air Force generation and continues throughout storage, handling, transfer, and servicing of the aircraft. Each operation in the aircraft gaseous oxygen supply system must be carried out in strict compliance with procedures established to assure safety of flight and mission completion.

NOTE

In Chapter 4, gaseous aviator's breathing oxygen will be abbreviated ABO.

4.2 SCOPE.

This chapter establishes procedures and requirements to assure the quality of ABO that is used by aircrews. It applies to base personnel who are responsible for supervising or performing the operations necessary to deliver ABO to aircraft.

4.3 INTENDED USE.

WARNING

Aviator's Breathing Oxygen shall not be used in welding applications.

Aviator's Breathing Oxygen is intended for use in aircraft life support systems and may be used in other similar applications. Cylinders of Aviator's Breathing Oxygen shall not be used for applications which only require a technical grade. This may introduce contaminants into the cylinders which are difficult to remove by ordinary methods and, thereby, increase the probability of supply of product which is unacceptable for its intended use.

4.4 PERSONNEL.

Personnel ordering, producing, and/or servicing ABO shall be trained in order to develop a thorough knowledge of its characteristics, its contaminants, and the systems in which it is used. Reliable and knowledgeable personnel are the key to an effective quality control program.

4.5 QUALITY CONTROL REQUIREMENTS OF AVIATOR'S GASEOUS BREATHING OXYGEN.

4.5.1 Procurement Limits. ABO must meet the requirements of specification MIL-PRF-27210. Procurement limits for odor, purity, moisture and minor constituents are contained in the specification and are shown in Table 4-1 of this technical order.

4.5.2 Procurement and Use Limits of Aviator's Gaseous Breathing Oxygen. See Table 4-1.

Table 4-1. Procurement and Use Limits

Odor	None
Purity (percent by volume)	99.5 (Min)
Carbon Dioxide (ppm by volume)	10 (Max)
Methane (ppm by volume)	50 (Max)
Acetylene (ppm by volume)	0.1 (Max)
Ethylene (ppm by volume)	0.4 (Max)
Ethane and other hydrocarbons (ppm by volume)	6 (Max)
Nitrous Oxide (ppm by volume)	4 (Max)
Halogenated Compounds: Refrigerants (freon, etc.) (ppm by volume) Solvents (trichloroethylene, carbon tetrachloride, HCFC-141b, and AK-225g, etc.) (ppm by volume)	 2 (Max) 0.2 (Max)
Other (ppm by volume)	0.2 (Max)
Moisture (ppm by volume) (dewpoint, degrees F)	 7 (Max) –82 (Max)

4.6 SUPPLY SOURCES OF AVIATOR'S GASEOUS BREATHING OXYGEN.

4.6.1 Commercial Generating Plants. Aviator's gaseous breathing oxygen procured from commercial generating plants must meet the requirements of the current issue of Specification MIL-PRF-27210. To ensure this, it is necessary that inspection by a government Quality Assurance Representative (QAR) be performed at the filling plant. Generally, it is required that the ordering activity send two copies of the purchase order to the office designated by DoD 4105.59-H or other inspecting activity authorized by DET 3, WR-ALC/AFTT so that they may schedule inspections. When an overseas oxygen plant is not operational and gaseous oxygen must be procured from a commercial source while awaiting plant repair, cryogenics personnel (AFSC 2F0X1 SEI 037) assigned to the requesting organization's cryogenics section may perform QAR inspections.

4.6.2 Air Force Operated Generating Plants. Aviator's gaseous breathing oxygen produced by Air Force generating plants must meet the requirements of the current issue of MIL-PRF-27210. MIL-PRF-27210 requires a 45-day periodic sample of the oxygen being produced by a generating plant. If production interval is longer than 45 days, then sample at each filling. When authorized by Major Air Force Command, medical oxygen cylinders may be filled with aviator's breathing oxygen in compliance with MIL-PRF-27210.

4.7 ON-BASE TESTING.

The on-base monitoring of aviator's gaseous breathing oxygen for contamination is performed by the following odor test:

Odor Test. Crack open the cylinder valve and smell the escaping gas.

4.8 PERIODIC OR REQUESTED TESTS FOR PURITY, KINDS, AND AMOUNTS OF CONTAMINANTS.

Tests shall be performed by the laboratories listed in Table 2-4. Other Air Force laboratories must be approved by DET 3, WR-ALC/AFTT or, in overseas areas, by Command Headquarters prior to use.

4.9 TESTS AFTER INCIDENTS AFFECTING FLYING PERSONNEL.

Samples taken after incidents in which flying personnel are affected, and any additional samples deemed necessary by the Director of Base Medical Services, will be submitted through Base Medical Service to one of the laboratories listed in Paragraph 2.33 or Table 2-4. Other laboratories may be approved by USAF Clinic DET 3, WR-ALC/AFTT.

a. The base organization responsible for taking samples shall notify DET 3, WR-ALC/AFTT by message/e-mail that a sample has been submitted. The date, method of shipment, and sample identification number shall be provided.

b. Taking samples from an aircraft oxygen system after an incident requires cooperation between the Base Fuels Management Office and the Aircraft Maintenance Office that normally maintains the oxygen system. The Base Medical Services shall not be required to take the sample from the aircraft systems.

c. Take samples from aircraft oxygen systems in accordance with applicable aircraft manuals.

d. The laboratory shall provide a copy of their analysis to DET 3, WR-ALC/AFTT.

4.10 RECEIPT OF AVIATOR'S GASEOUS BREATHING OXYGEN FROM A CONTRACTOR.

Before accepting a shipment of filled cylinders, check the DD Form 250 to ensure that inspection has been accomplished (Paragraph 4.6.1). A signature of the QAR or Alternative Release Procedure note is required. Upon receipt of product from a contractor, on-base sampling and testing of the contents of the cylinders are not required; however, each cylinder shall be inspected for the following:

a. Proper painting and marking.

b. Valves are tightly closed.

c. Safety caps or safety plugs are leak-tight and secure.

d. Valves protective caps are installed.

e. Grease or oil on the valves or cylinders. The presence of grease or oil on the valves or cylinders shall be reported immediately to the Transportation Officer for necessary action.

4.11 AIR FORCE OPERATED GENERATING AND CHARGING PLANTS.

Aviator's gaseous breathing oxygen shall be produced and filled (charged) into cylinders in accordance with the instructions of the applicable oxygen generating plant operation and service manuals after being processed according to Paragraph 4.19.

4.11.1 Production and Cylinder Filling of Aviator's Gaseous Breathing Oxygen..

a. Test sample of oxygen for purity at the Oxygen Sample Valve. OXYGEN PURITY MUST BE 99.5% OR HIGHER. Tests for purity shall be made frequently to assure required minimum purity during production and cylinder filling.

b. When test indicates required product purity, purge high-pressure oxygen line by opening the pump-oxygen feed control valve and start up oxygen-nitrogen pump. Purge charging manifold and feed lines.

c. Test oxygen for odor at the manifold branch to which each cylinder is attached. If odor is detected, do not fill cylinder until corrective action is taken and odor is no longer detected.

d. Once every 45 days and whenever contamination is suspected, a sample shall be taken from the generator manifold system and sent to a designated laboratory (Paragraph 2.10 and Paragraph 2.12) to be tested for limits specified in Table 4-1.

NOTE

If production interval is longer than 45 days, then a sample will be submitted from each filling.

e. Fill cylinders attached to the charging manifold to the required pressure.

4.12 CONTRACTS FOR MAINTENANCE OF CYLINDERS FILLED AT AIR FORCE GENERATING AND CHARGING PLANTS.

When repair or replacement of valves, cylinder drying, or other maintenance described in the paragraphs below is to be performed by a vendor, the contract should contain the requirements of MIL-STD-1411, Inspection and Maintenance of Compressed Gas Cylinders.

4.13 INSPECTION AND PROCESSING OF CYLINDERS FILLED AT AIR FORCE GENERATING AND CHARGING PLANTS.

Each filled cylinder before removal to storage shall be inspected and processed as follows:

a. Leak Test – each cylinder shall be tested for leakage by brushing Leak Test Compound, Oxygen Systems, MIL-PRF-25567, over the cylinder and all portions of the valve, except the valve outlet. Each cylinder shall be tested for leakage through the valve, when closed, by means of a tube from the valve outlet to a container of water. Care should be taken to insure that water or leak test compound is not brought into contact with the valve outlet.

(1) Leaking Valves – cylinders found to leak through the valve or at the junction between the valve and the cylinder shall be emptied to 0 psig and processed as follows:

(a) Emptying (bleeding) Cylinders – slightly crack open the cylinder valve. Test for odor (Step (b)). When pressure is reduced below the noise level, valves may be fully opened. All cylinders shall be bled in the open at a safe distance from any source of ignition.

(b) Presence of Odor – if odor is detected during cylinder emptying (bleeding), the cylinder is not suitable for refilling and shall be cleaned or processed in accordance with the procedures given in T.O. 42B5-1-2, for deodorizing cylinders.

(c) Valve Removal – remove valves in accordance with T.O. 42B5-1-2.

(d) Internal Inspection – after the valve is removed, inspect the interior of the cylinder with a drop light for the presence of rust, scale, and foreign material. A drop light of sufficient intensity to clearly illuminate the internal wall and bottom of the cylinder is mandatory for internal inspection.

(e) Removal of Internal Scale and Rust – remove scale and rust in accordance with the procedure in T.O. 42B5-1-2. Flush cylinder with clear water and dry in accordance with Paragraph 4.20 of this technical order.

(f) Valve Replacement – install a new valve conforming to Specification MIL-DTL-2 and in accordance with T.O. 42B5-1-2. Valves shall be tightened into the cylinder with a torque of 250 – 275 ft-lbs. When a cylinder is subjected to cylinder processing of Step a(1)(b) or (e), the cylinder valve shall not be replaced until the cylinder is dried in accordance with Paragraph 4.20 of this technical order.

(2) Leaking Cylinders – cylinders found to leak through the cylinder wall are not suitable for refilling and shall be emptied to 0 psig, and shall be processed in accordance with Paragraph 4.21 of this technical order.

b. Attach valve outlet (dust) cap.

c. Wire AFTO Form 407, bearing the following information to the cylinder valve:

1. Filling Date ______
2. Lot Number ______
3. Odor Test PASS (see Paragraph 4.14, Step b)
4. Leak Test PASS
5. Final Filling Pressure ______

d. Screw valve protection cap securely on cylinders.

4.14 QUALITY CONTROL OF CONTENTS OF CYLINDERS FILLED AT AIR FORCE GENERATING AND CHARGING PLANTS.

Each filled cylinder shall be tested for odor. Sample cylinders shall be selected in accordance with Step a and their contents tested for purity.

a. Selection of Sample Cylinders – each set of cylinders charged on the same manifold at the same time shall constitute a lot. The number of sample cylinders per lot shall conform to the following sampling plan:

Number of Sample Cylinders	Lot Size
1	1 to 10
2	11 to 40
3	41 to 70
4	71 and up

b. Test for Odor – the contents of each filled cylinder shall be tested for odor by attaching a suitable regulator, adjusting the cylinder and regulator valves to obtain a gentle flow, and smelling the escaping gas. If odor is detected in the escaping gas, the filled cylinders shall be rejected.

c. Test for Purity – the contents of each sample cylinder selected in accordance with Step a above shall be tested for purity according to methods of Specification MIL-PRF-27210. Items a and b of Table 4-2 identify two ways of testing which are acceptable. The contents of the sample cylinder shall not contain less than 99.5% oxygen by volume. (See Paragraph 4.17, Rejection and Retests.)

4.15 PERIODIC SAMPLING GASEOUS OXYGEN CHARGING SYSTEM.

Attach the sampler to the charging manifold system during the normal processing of a bank of cylinders. Charge the cylinders in accordance with Paragraph 4.11. Remove sampler and inspect for leaks as described in Paragraph 4.13. Identify sample by completing AFTO Form 176 and attaching it to the sampler valve.

4.16 TESTS, METHODS, AND TEST EQUIPMENT.

See Table 4-2.

4.17 REJECTION AND RETESTS.

a. Odor Test Failure.

(1) When one cylinder or a small portion of cylinders charged from the same manifold at the same time fail the odor test, the cylinders are not suitable for refill. The cylinders shall be rejected, emptied to 0 psig pressure, and processed in accordance with the procedures given in T.O. 42B5-1-2 for deodorizing cylinders.

(2) When all cylinders charged from the same manifold at the same time fail the odor test, the cylinders shall be rejected and emptied to 0 psig pressure and processed in accordance with Paragraph 4.20 before refilling. Do not fill any more cylinders until the cause and source of the odor is determined and corrective action has been taken.

b. Sample Cylinder Test Failures.

(1) When one or more sample cylinder(s) from a lot fail any of the quality control test requirements of Paragraph 4.14, Steps b and c, the sample cylinder(s) shall be rejected, and acceptance of all cylinders in the lot shall be withheld until the cause and source of test failure(s) is determined.

(2) If the investigation shows that the sample cylinder(s) test failure is due to the gaseous oxygen produced by the plant, the entire lot shall be rejected. Do not fill any more cylinders until corrective action has been taken.

Table 4-2. Tests, Methods and Test Equipment

NSN No. and/or Part No.	Nomenclature	Test Method
a. 6630-00-507-0584 and/or P/N 47966D or equivalent	Oxygen-Nitrogen Test Set Assembly	In accordance with applicable Oxygen Generating Plant Operation and Service Manual
b. 6630-01-101-3079 and/or P/N 570A or equivalent	Oxygen Analyzer	According to the instrument operation manual
c. RR-C-901/1, with valve MIL-DTL-2/39	Oxygen Cylinder (sampler)	In accordance with Paragraph 4.15

(3) Rejected cylinders shall be processed in accordance with Paragraph 4.20.

4.18 PROCESSING OF EMPTY CYLINDERS TO BE RETURNED FOR REFILLING.

Prior to shipping EMPTY cylinders for refilling, each cylinder shall be inspected and processed in accordance with T.O. 42B5-1-2.

4.19 PROCESSING OF EMPTY CYLINDERS RECEIVED AT AIR FORCE OPERATED GENERATING PLANTS FOR REFILLING.

Prior to refilling cylinders which have been received at Air Force operated generating plants, each cylinder shall be inspected and processed as follows:

a. Inspecting and Processing External Condition and Hydrostatic Test Date.

(1) Grease and Oil – any trace of grease or oil on the surface of a cylinder shall be removed before filling.

(2) Rust, Scale, Caked Paint, and Dirt – any loose rust, scale, caked paint, and dirt shall be removed so that the external surface can be adequately inspected.

(3) Dents, Cuts, Gouges, Digs, Bulges, Pitting, and Corrosion – each cylinder shall be inspected for the presence of these conditions. Inspection of the cylinder bottom is important because experience has shown this area is the most susceptible to corrosion. When any of the above conditions exist to the extent that the structural strength of the cylinder may have been weakened, the cylinder shall be rejected for filling. Depending upon the condition and its extent, the cylinder shall be tested for structural weakness or condemned and disposed of in accordance with Paragraph 4.21. Experience in the inspection of cylinders is a necessary factor in determining the acceptability of a cylinder for continued service. The removal of cylinders from service is therefore based on the experience and judgement of the inspector.

(4) Painting, Stenciling, and Marking – each cylinder shall be inspected for proper painting, stenciling, and marking as required by T.O. 42B5-1-2.

(5) Cylinder Valve Inspection – each cylinder valve shall be inspected for proper condition and functioning. If a valve is found to be damaged, inoperative, or otherwise unsatisfactory, install a new valve in accordance with Paragraph 4.13, Step a(1)(c) through (f).

(6) Hydrostatic Test Date Inspection – each cylinder shall be inspected to determine the last date of hydrostatic testing. If the last date of testing was five or more years prior to the intended filling date, the cylinder shall be processed in accordance with T.O. 42B5-1-2. If the last date of testing was less than five years prior to the intended filling date, and the cylinder has passed all the requirements of Step a (1) through (5), the cylinder shall be processed for filling in accordance with Step b (1) and (2).

b. Inspecting and Processing Internal Condition.

(1) Positive Pressure and Odor Inspection – each cylinder shall be checked for positive internal pressure and odor. Unless a pressure gage is used to insure that a cylinder has at least a 5 psig internal pressure, a slip of paper shall be used to insure that any hissing sound, heard when the valve is cracked open, is due to a positive pressure rather than a vacuum. A cylinder with less than 5 psig pressure (or insufficient pressure to cause an audible hissing sound) or with an odor in the escaping gas shall be processed in accordance with Paragraph 4.20. If moisture is suspected, the cylinder may be inverted and the remainder of the internal pressure used to force out any separated water. If water is detected, the cylinder shall be dried in accordance with Paragraph 4.20. A cylinder having positive pressure and no odor shall be processed in accordance with Step b (2) for filling.

(2) Residual Gas Removal – each cylinder to be filled shall be evacuated to an absolute pressure of less than 3 inches of mercury, then filled to 5 psig and reevacuated to an absolute pressure of less than 3 inches of mercury. The cylinder shall then be filled from this evacuated condition.

4.20 CYLINDER DRYING.

Cylinders shall be dried by either the hot gas purging method or the evacuation method, specified in T.O. 42B5-1-2. After filling, each cylinder dried by one of these methods shall be tested for odor (Table 4-2). If an odor is detected, the cylinder shall be rejected, emptied to 0 psig pressure, and processed in accordance with the procedure given in T.O. 42B5-1-2 for deodorizing cylinders.

4.21 REJECTED CYLINDER DISPOSITION.

Cylinders rejected or condemned for any reason as unsuitable for further use shall be processed in accordance with the requirements of T.O. 42B5-1-2.

4.22 INSPECTION AND TEST RECORDS.

Each Air Force Operated Generating and Charging Plant shall maintain inspection and test records covering production, inspection, and processing of EMPTY cylinders, and inspection and testing of filled cylinders. Such inspection and test records shall include:

a. Results of tests for oxygen purity at the Oxygen Sample Valve during production. (See Paragraph 4.11, Step a.)

b. Inspection of filled cylinders (Paragraph 4.13).

(1) Leak Test.

(2) Internal inspection, cleaning, and replacement of valves, if required.

c. Inspection of contents of filled cylinders (Paragraph 4.14).

1. Lot Number

2. ICC Serial Number of each cylinder in the lot

3. Odor Test

4. DOT Serial Number of each sample cylinder selected from the lot and the test results for purity

d. Inspection and processing of EMPTY cylinders received for refill.

4.23 SERVICING TRAILERS.

AFTO Form 134. AFTO Form 134 shall be maintained on gaseous oxygen servicing trailers. Below are instructions for filling out this form which records three distinct operations – replacing oxygen cylinders, replacing purifier cartridges, and servicing aircraft. The entries for each operation shall be made on separate rows of the form and shall be initialed by an individual of the organization performing the operation.

a. The organization making the initial entry on the form shall enter trailer serial number in appropriate block.

b. The organization replacing the cylinders shall enter the following:

1. Date of Replacement

2. Number of Cylinders Replaced

3. The Aggregate Total – the aggregate total is the number of cylinders replaced since the last replacement of the purifier cartridge.

c. The organization replacing the purifier cartridge shall enter the date of replacement.

d. The organization servicing the aircraft shall enter the following:

1. Date of Servicing

2. Initial Pressure of Aircraft System

3. Final Pressure of Aircraft System

4. Serial Number or Tail Number of the Aircraft Serviced

e. The organization servicing the aircraft shall maintain the file of AFTO Forms 134. This file may be maintained on the servicing trailer. Forms may be destroyed two weeks after the date of the last recorded aircraft servicing.

4.24 HAZARDS AND SAFETY PRECAUTIONS IN HANDLING CYLINDERS OF GASEOUS AVIATOR'S BREATHING OXYGEN.

Gaseous Oxygen: As a compressed gas, the principle hazard is due to the rocket-like thrust imparted to the cylinder by the sudden and rapid escape of the gas. For example, if the valve of a cylinder at 2500 psig is broken off, the cylinder would have an initial thrust of about 2600 pounds force. The cylinder could attain a velocity of 50 feet per second in about one tenth of a second. An additional potential hazard arises from the increase in pressure of the compressed gas with any increase in temperature. Cylinders may explode with great violence, or safety plugs may be blown out if the cylinders are exposed to higher than normal temperatures. Mechanical or structural damage may also cause failure of a cylinder. Compressed gas cylinders are built to withstand normal hard usage, but they must not be subjected to abuse. Serious accidents connected with their handling, use and storage have invariably been traced to abuse or mishandling.